

# Odontologisk Revvy

VOLUME 25  
SUPPLEMENT 30  
1974

---

## Treatment of non-vital permanent incisors with calcium hydroxide

Studies of periradicular healing, apical closure and external  
root resorption in invaginated, luxated or root-fractured teeth

---

BY MIOMIR CVEK

GWK GLEERUP, LUND 1974

---



Digitized by the Internet Archive  
in 2026

# Odontologisk Revvy

VOLUME 25

SUPPLEMENT 30

1974

---

## Treatment of non-vital permanent incisors with calcium hydroxide

Studies of periradicular healing, apical closure and external  
root resorption in invaginated, luxated or root-fractured teeth

---

BY MIOMIR CVEK

CWK GLEERUP, LUND 1974

---

Translated by L. James Brown



Berlingska Boktryckeriet, Lund 1974

From the Departments of Pedodontics and Oral Histopathology, University of Lund, School of Dentistry, Malmö, and the Department of Oral Roentgendiagnosis, School of Dentistry, University of Gothenburg, Gothenburg, Sweden

The present thesis summarises the following papers:

- I Cvek, M., 1972, Treatment of non-vital permanent incisors with calcium hydroxide. I. Follow-up of periapical repair and apical closure of immature roots. *Odont. Revy*, 23, 27.
- II Cvek, M., 1973, Treatment of non-vital permanent incisors with calcium hydroxide. II. Effect on external root resorption in luxated teeth compared with effect of root filling with guttapercha. A follow-up. *Odont. Revy*, 24, 343.
- III Cvek, M., Granath, L.-E. and Hollender, L., 1974, Treatment of non-vital permanent incisors with calcium hydroxide. III. Variation of occurrence of ankylosis of reimplanted teeth with duration of extra-alveolar period and storage environment. *Odont. Revy*, 25, 43.
- IV Cvek, M., 1974, Treatment of non-vital permanent incisors with calcium hydroxide. IV. Periodontal healing and closure of the root canal in the coronal fragment of teeth with intra-alveolar fracture and vital apical fragment. A follow-up. *Odont. Revy*, 25, in press.
- V Cvek, M. and Sundström, B., 1974, Treatment of non-vital permanent incisors with calcium hydroxide. V. Histologic appearance of roentgenographically demonstrable apical closure of immature roots. *Odont. Revy*, 25, in press.

These papers are referred to by their Roman numerals.





## INTRODUCTION

Pulpal necrosis is common in luxated young permanent incisors. Toxic products from necrotic and/or infected pulp impair healing of intra-alveolar root fracture and may impair healing of external root resorption. Adequate cleaning and obturation with guttapercha of the root canal of young permanent teeth with often apically diverging canal and a wide apical foramen is difficult. As an alternative to obturation with guttapercha immediately after antibacterial pretreatment, treatment with calcium hydroxide has been described in several case reports and clinical after-examinations (for review, see I). Treatment with calcium hydroxide is said to result in the formation of apical hard tissue barrier, against which the canal can be obturated satisfactorily with guttapercha. Calcium hydroxide has usually been mixed with other substances such as camphorated monochlorophenol, camphorated parachlorophenol and methyl cellulose. The results have, however, been judged mainly from the state of the hard tissue formation at the apex. Roentgenologically, this has been interpreted either as a sealing barrier of the canal in a root, whose development has been arrested, or as continued root formation. Besides the formation of an apical hard tissue barrier, the treatment with calcium hydroxide should also promote healing of inflammatory changes in adjacent tissue as well as arrest of external root resorption.

Teeth with intra-alveolar root fracture often exhibit pulpal necrosis only in the coronal fragment (Andreasen and Hjørting-

-Hansen 1967). From a therapeutic point of view the coronal fragment may therefore in such cases be compared to a non-vital tooth with an immature root. Treatment with calcium hydroxide has hitherto not been reported.

The histologic appearance of the hard tissue forming the apical closure in non-vital permanent teeth with an immature root has, with one exception (Heithersay 1970), been described only in experimental studies on animals (Steiner et al 1971, Dylewski 1971, Ham et al 1972, Torneck et al 1973, Binnie and Rowe 1973). However, concerning therapeutically treated human teeth detailed knowledge of the histologic appearance of the substance which is seen roentgenographically as the apical closure has hitherto been lacking.

The relation between pulpal necrosis and progression of external root resorption, which is associated with inflammatory changes in adjacent bone, has been emphasised by Andreasen and Hjørting-Hansen (1966 a and b) in investigations of reimplanted teeth. No such relation could be demonstrated experimentally in the dog by Hovinga (1968), but has been confirmed in the rat by Andreasen (1973).

Andreasen and Hjørting-Hansen (1966 a) reported arrest of root resorption associated with radiolucency of adjacent bone in 4 out of 28 reimplanted teeth with a mature root, whose canal had been filled with guttapercha. Andreasen (1971), however, reported healing of such resorption after treatment with calcium hydroxide in all cases in a series of 9 reimplanted teeth which had an immature root. Since no further investigations had been published on the frequency of healing, it was not known whether the difference in frequency of healing between these two materials was due only to the treatment with calcium hydroxide or whether the stage of development of the root had been of any significance. Neither was it known whether the healing frequency had been influenced to any extent by periodontal damage, acquired during the extra-alveolar interval, which primarily leads to ankylosis.



It is clear from the above that the literature on the treatment of young non-vital teeth with calcium hydroxide permitted neither estimation of the frequency of successful treatment in respect of apical closure nor a clear picture of the course of healing on inflammatory changes in the tissues surrounding the tooth. Neither did the literature give any clear information about the relation between pulpal necrosis and external root resorption and the effect of the endodontic treatment.

The purpose of the present investigation was therefore to study the effect of treatment of young permanent non-vital teeth with calcium hydroxide, regarding

1. periapical healing and apical hard tissue formation (I),
2. periodontal healing and hard tissue formation at the apical opening of the coronal fragment of intra-alveolarly root-fractured teeth (IV),
3. the histologic appearance of the tissue constituting the apical hard tissue barrier (V),
4. arrest of external root resorption in intra-alveolarly luxated teeth compared with the effect of root filling with gutta-percha (II) and
5. the occurrence of ankylosis of reimplanted teeth in relation to extra-alveolar time and storage environment (III).

## MATERIAL AND METHODS

The primary material was collected at the Eastman Institute in Stockholm. It consisted of 1) all 421 upper incisors and of all 4 lower reimplanted incisors, which owing to clinically diagnosed pulpal necrosis, had had their roots treated and temporarily filled with calcium hydroxide between 1962 and 1971, and 2) all 572 upper luxated incisors which, because of clinically diagnosed pulpal necrosis, had had their roots treated and filled with chloroperca-guttapercha between 1957 and 1964.

The teeth for the present studies were selected from the primary material on the basis of the following clinical and roentgenologic criteria:

- I. 1) total pulpal necrosis, 2) periapically widened, diffusely outlined periodontal space or periapical radiolucency and 3) incompletely developed root with no hard tissue at apical foramen before treatment,
- II. 1) accidental intra-alveolar luxation and 2) roentgenographically demonstrable loss of tooth substance on the root surface associated with widened, diffusely outlined periodontal space or radiolucency,
- III. 1) accidental luxation out of the alveolus and 2) reimplantation,
- IV. 1) non-vital pulp in the coronal fragment of root-fractured teeth, 2) sensible tissue to the probe in the apical fragment, periapically surrounded by periodontal space bordered by lamina dura, and 3) roentgenographically demonstrable diastasis between the fragments, and

- V. extracted teeth with 1) total pulpal necrosis, 2) periapical radiolucency before treatment, 3) periapical healing at some instance before extraction and 4) roentgenographically demonstrable complete apical closure.

After selection according to these principles, the material in papers I, II CH (with calcium hydroxide treated teeth), II G (with guttapercha root-filled teeth), III, IV and V, consisted of 55, 51, 33, 38, 17 and 12 teeth, respectively. The whole material consisted of 178 teeth in 172 children, aged 5 to 17 years (average 11 years). Of 145 teeth treated with calcium hydroxide, 78 were treated first by the author and 67 by other 19 dentists. Later treatment consisting of re-filling of the roots with calcium hydroxide and permanent root filling with guttapercha was performed by the author in 124 teeth. The teeth were treated according to principles outlined in I.

The stage of development of the teeth was judged from the width of apical foramen (I-III). The roentgenograms taken at the beginning of treatment were magnified 5 times by means of a photographic enlarger. The width of the apical opening of the canal was measured on the enlarged images with a rule graduated in millimeters. The widths were measured to the nearest half of whole millimeter. The values were then divided by the degree of enlargement, i.e. 5. If the apical foramen was at most 0.5 mm the root was regarded as mature, otherwise as immature.

Pulpal necrosis had been caused by infection through a palatal invagination in 10 teeth and in the others it was due to luxation and/or root fracture. Before filling with calcium hydroxide or guttapercha-chloropercha, the root canals were cleaned mechanically, flushed and treated antibacterially until cultured samples gave no growth. In 4 teeth antibacterial dressing was not applied. Distribution of drugs used for flushing and dressing is given in Table 1. The teeth were treated with calcium hydroxide for 6 months to 5 years (average 18 months).

The teeth for the histologic study (V) were fixed in an acetic acid-alcohol-formalin mixture or glutaraldehyde in a cacodylate buffer. Demineralisation was done in EDTA at neutral pH. The teeth were embedded in paraffin or, following post fixation in osmium tetroxid in Epon<sup>®</sup>. Sections were taken at different depths (at least 10) through the apical area. All teeth were studied with light microscopy and 4 of them with electron microscopy.

### Clinical criteria

Apical closure (I and IV) was tested by probing. Reimplanted teeth (III) were examined in respect of mobility, percussion sound and infraposition, and teeth with intra-alveolar root fracture (IV) in respect of mobility compared with that of adjacent teeth.

### Roentgenologic criteria

The results of treatment were evaluated from roentgenograms taken before and at the end of primary endodontic treatment and at follow-ups at 3 or 6 month intervals of teeth treated with calcium hydroxide and, at 6 or 12 month intervals, of teeth root-filled with chloropercha-guttapercha.

The roentgenograms were studied in respect of apical hard tissue closure (I,III and V) or hard tissue closure of the root canal in the coronal fragment (IV), healing of inflammatory changes in periodontium and bone (I-V), arrest of external root resorption (II) and of periodontal healing after reimplantation or occurrence of progressive root resorption in reimplanted teeth (III).

Apical closure of root canals was said to be complete if demonstrated roentgenographically and attested by probe (I) or if guttapercha did not pass through barrier into periapical

(III) or into interfragmentary area (IV) at the obturation of the canal.

Periodontal healing was said to have taken place if a periodontal space bordered by lamina dura was present at the end of treatment with calcium hydroxide or at the end of the control period of teeth filled with guttapercha.

If the periodontal space was widened and diffusely outlined or if radiolucency was present, it was rated as no healing.

Arrest of external resorption was said to exist if no increase in loss of tooth substance had been observed after treatment and if the resorption defect was surrounded by a re-established periodontal space bordered by lamina dura.

Resorption was considered not to have been arrested if loss of tooth substance had progressed with 1) coexisting residual or progressing inflammatory changes in adjacent periodontium and bone, demonstrated as widened, diffusely outlined periodontal space or radiolucency, or 2) lack of periodontal space and lamina dura in association with continuous substitution of lost tooth substance by bone (ankylosis).



## RESULT

### I - IV

The results are given in Tables 2 - 5.

Table 2 gives the healing frequency of all teeth studied, irrespective of the initial periradicular status, and in Table 3 the frequency is given only for those teeth which before treatment showed widened, diffusely outlined periodontal space or radiolucency adjacent to some part of the root. The healing frequency was equally high, 95 %, in the latter group as in the material as a whole.

Roentgenographically demonstrable apical closure and closure of the canal by hard tissue in the coronal fragment of root-fractured teeth are presented in Table 4. The same table also gives the periodontal status of the involved teeth at the end of treatment. The frequency of healing of the periodontal tissue ranged from 90 % (I) to 100 % (IV). The frequency of complete apical closure in association with periodontal healing, varied between 69 % (III) and 91 % (I).

External root resorption associated with inflammatory changes in adjacent tissues was arrested in all intra-alveolarly luxated teeth treated with calcium hydroxide except in 1, and in all guttapercha filled teeth except 2. Table 5 gives the occurrence of progressive external root resorption associated with ankylosis.

Furthermore, Table 5 shows that external root resorption associated with radiolucency in adjacent bone was not observed

after treatment with calcium hydroxide of reimplanted teeth. The frequency of external root resorption associated with ankylosis, on the other hand, was high, 45 %. This was thought to justify statistical evaluation of the occurrence of ankylosis with respect to extra-alveolar time and significance of storing the tooth in dry and/or wet environment.

Healing after reimplantation was found in incisors which had been kept dry for at most 40 minutes. Those that had been kept dry for more than 15 minutes were kept in isotonic solution, saliva or physiologic saline, for more than 20 minutes before they were reimplanted.

Those 19 teeth in which resorption with ankylosis was demonstrated were not included in Tables 2, 3 and 4 partly because ankylosis is regarded as primarily related to the periodontal injury caused by luxation and, partly, because it was not possible to judge apical closure in teeth with ankylosis in the apical part of the root.

The reimplanted teeth (III) were not judged with respect to initial inflammatory changes because such changes could not be distinguished from those due to erroneous reposition. They are therefore not included in Table 5.

## V

The tissues of and around the apical closure showed very mild inflammatory changes in 4 teeth and a more marked reaction in 1 tooth. The apical hard tissue consisted of new-formed cementum-like tissue as well as of calcified areas.

Cementum-like tissue spanned the area between the root canal in many sections, but it was only in 3 teeth that all sections showed complete apical closure. Loose connective tissue

of a usually non-inflamed appearance was always seen within the hard tissue barrier. In 1 of the teeth that had been filled with guttapercha the loose connective tissue interspersed within an incomplete barrier was free of inflammation and showed only closely lined up macrophages.

The calcified areas had a very variable morphology. Ultrastructurally, they appeared to be of two types. One type contained dark-staining, coarsely granulated parts surrounded by homogeneous, banded areas with bulbous contours. The other type, more frequently observed, had a light-staining finely granular or globular appearance. This type of calcified areas was often found at the periphery of the other one, but mostly in connection with new-formed hard tissue. Calcified areas showed no untoward effects on the peripheral tissue and were frequently buried within new-formed cementum-like tissue. In 1 case an inflammatory reaction, which had been roentgenographically demonstrated before extraction, was present close to isolated calcified areas; these were resorbed by multinucleated giant cells.

## DISCUSSION AND CONCLUSIONS

All of the roentgenograms studied in the present investigation were generally of high quality both in respect of geometric projection and photographic density. At every treatment and every examination usually 2 roentgenograms had been obtained with standardised adjustments using different angles. This implied that even relatively small changes in the tooth and the surrounding tissue could be evaluated with satisfactory certainty. The frequency figures should therefore be judged against this background. For example, it was possible to find small losses of tooth substance on the surface of the root, associated with changes in adjacent tissue. It is therefore also possible that some teeth with resorption of a superficial character (Andreasen 1970) in which spontaneous arrest might have occurred, were included in the material. Such conditions might have contributed to the high frequency of success.

The frequency of roentgenographically demonstrable healing of periradicular inflammation related to pulpal necrosis was invariably high irrespective of the initial extent and site of the inflammation and of the degree of maturity of the root except in those cases where the periodontal injury had caused ankylosis.

The frequency of roentgenographically demonstrable complete closure with simultaneous periapical healing of teeth with immature root was high. The reason for the lower frequency of complete apical closure of the root canal in the coronal part of the root-fractured teeth could not be explained with any certainty, especially since all of them showed periodontal healing.

The significance of the effect of the antibacterial pre-

treatment on the periapical healing and on the apical hard tissue formation could not be elucidated in the present investigation. In experimentally infected dogs' teeth Matsumiya and Kitamura (1960) found no difference in the healing between teeth treated with antiseptics and antibiotics and teeth that had been rinsed only with sterile saline before the roots had been filled with calcium hydroxide. The favourable effect of calcium hydroxide on periapical healing may be explained by its acting as a long-term antibacterial dressing. The antibacterial pretreatment may, however, have caused reorganisation of inflamed periapical tissue.

The roentgenologic diagnosis of periapical healing was supported by the histologic findings. Few and mild inflammatory changes were observed in the tissues that formed the apical closure. Those found could, in most cases, be roentgenologically verified and related to the secondary accident that was the cause for extraction.

Complete apical closure, as judged from the roentgenograms, could be demonstrated histologically in only 3 of the 12 teeth in V. The apical barrier showed a varying amount of vital, usually uninflamed loose connective tissue in all the histologic sections. Those teeth in which the root had been filled with gutta-percha before extraction had established a mechanically resistant barrier. In one of these cases guttapercha was found in contact with loose connective tissue in the hard tissue barrier with phagocytosis as the only reaction. Thus sealing with gutta-percha, provided that it has been done in a germ-free canal, should not produce other reactions.

Calcified areas, most often buried in or covered by new-formed cementum-like tissue towards the periodontium, most probably have little or no effect on the final result of treatment. Such isolated areas caused no inflammatory response of surrounding loose connective tissue.

The effect of endodontic treatment on arrest of external root



resorption associated with inflammatory changes in surrounding tissues, was studied in intra-alveolarly luxated teeth, because it is known that ankylosis is seldom seen in such teeth (Andreasen 1970). That no difference in frequency of healing was found between those treated with calcium hydroxide and those filled with guttapercha, which has not been shown before, suggested that removal of necrotic pulp is decisive for the arrest of resorption, except in cases where resorption is also related to a periodontal injury causing ankylosis. This conclusion is confirmed by the absence of external root resorption associated with osteolysis in adjacent bone in the reimplanted, endodontically treated teeth and supports the postulation by Andreasen and Hjørting-Hansen (1966 a) concerning the relation between necrotic pulp and progression of external root resorption.

The absence of external root resorption associated with osteolysis in adjacent bone in reimplanted teeth contrasts with the high frequency of such resorption in other published series, such as that by Andreasen and Hjørting-Hansen (1966 a). They found the frequency of 39 % in teeth filled with guttapercha. The difference might depend on an effect of calcium hydroxide on necrotic remnants unintentionally left behind at cleaning of the canal in such a way as to arrest irritation of the periodontal tissue.

In reimplanted teeth ankylosis was the only complication after treatment with calcium hydroxide. The statistical analysis showed that the frequency of ankylosis was lower in teeth which had been stored dry for a moderate time and afterwards kept for a moderate time in isotonic environment than in those only kept dry. This observation, which has not been pointed out before, must be judged with caution, but it suggests a working hypothesis for experimental testing.

Recommendation for clinical use, even though it does not imply a guarantee for healing, is that the teeth that are

stored dry for more than 15 minutes should be stored in isotonic solution for, say, 30 minutes, before reimplantation. The positive effect of storing dry teeth in saliva or physiologic saline may depend on the possibility that degradation products of autolysed cells or other tissue components are washed off the root surface.

## REFERENCES

- ANDREASEN, J. O., 1970, Luxation of permanent teeth due to trauma. Scand. J. dent. Res., 78, 273.
- ANDREASEN, J. O., 1971, Treatment of fractured and avulsed teeth. J. Dent. Child., 38, 29.
- ANDREASEN, J. O., 1973, Effect on pulpal necrosis upon periodontal healing after surgical injury in rats. Int. J. oral Surg., 2, 62.
- ANDREASEN, J. O. and HJÖRTING-HANSEN, E., 1966 a, Replantation of teeth. I. Radiographic and clinical study of 110 human replanted teeth after accidental loss. Acta odont. scand., 24, 263.
- ANDREASEN, J. O. and HJÖRTING-HANSEN, E., 1966 b, Replantation of teeth. II. Histological study of 22 replanted anterior teeth in humans. Acta odont. scand., 24, 287.
- ANDREASEN, J. O. and HJÖRTING-HANSEN, E., 1967, Intraalveolar root fractures: radiographic and histologic study of 50 cases. J. oral Surg., 25, 414.
- BINNIE, W. H. and ROWE, A. H. R., 1973, A histological study of the periapical tissues of incompletely formed pulpless teeth filled with calcium hydroxide. J. dent. Res., 52, 1110.
- DYLEWSKY, J. J., 1971, Apical closure of non-vital teeth. Oral Surg., 32, 82.
- HAM, J. W., PATTERSON, S. S. and MICHELL, D. F., 1972, Induced apical closure of immature pulpless teeth in monkeys. Oral Surg., 33, 438.
- HEITHERSAY, G. S., 1970, Stimulation of root formation in incompletely developed pulpless teeth. Oral Surg., 29, 620.
- HOVINGA, J., 1968, Replantatie en transplantatie van tanden. Een experimenteel en klinisch onderzoek. Oosterbaan & Le Cointre N V-Goes, Amsterdam.
- MATSUMIYA, S. and KITAMURA, M., 1960, Histo-pathological and histo-bacteriological studies of relation between the condition of sterilization of the interior of the root canal and the healing processes of periapical tissues in experimentally infected root canal treatment. Bull. Tokyo dent. Coll., 1, 1.

STEINER, J. C. and VAN HASSEL, H. J., 1971, Experimental root apexification in primates. Oral Surg., 31, 409.

TORNECK, C. D, SMITH, J. S. and GRINDALL, P., 1973, Biologic effects of endodontic procedures on developing incisor teeth. Oral Surg., 35, 541.





Table 1. Distribution of drugs used in cleaning and sterilising procedures in the root canals before filling with calcium hydroxide (CH) or chloropercha-guttapercha (G).

| Number of teeth                        | I<br>55 | IICH<br>51 | IIG<br>33 | III<br>38 | IV<br>17 | V<br>12 |
|----------------------------------------|---------|------------|-----------|-----------|----------|---------|
| Rinsed with:                           |         |            |           |           |          |         |
| Sterile saline                         | 6       | 19         | 15        | 25        | 14       | 7       |
| 1 % Biosept (® x)                      | 49      | 26         | 15        | 8         | 3        | 5       |
| Dakin's solution xx)                   |         | 6          | 3         | 5         |          |         |
| Antibacterial dressing:                |         |            |           |           |          |         |
| 2 % iodine potassium iodide            | 1       | 4          | 3         | 2         | 1        |         |
| 5 % "-                                 | 1       | 13         | 2         | 6         | 4        |         |
| 10 % Chloromycetin Topical (® xxx) and | 48      | 26         | 26        | 11        | 10       | 5       |
| 10 % "-                                |         |            |           |           |          |         |
| 2 or 5 % iodine potassium iodide       | 3       | 8          | 2         | 17        | 2        | 7       |
| No antibacterial dressing              | 2       |            |           | 2         |          |         |

x) Recip

xx) sodium hypochlorite giving about 0.5 % active chlorine

xxx) Parke Davis

Table 2. Results of roentgenologic evaluation of periodontal healing in teeth with or without roentgenographically demonstrated initial inflammatory changes, i.e. of periapical healing (I) and/or periodontal healing (II, III and IV) after treatment with calcium hydroxide, distributed according to mature (m) or immature (im) root; teeth showing ankylosis are excluded.

|                                               | I  | II |    | III             |                 | IV | Tot        |
|-----------------------------------------------|----|----|----|-----------------|-----------------|----|------------|
|                                               | im | m  | im | m               | im              |    |            |
| Number of teeth                               | 55 | 6  | 44 | 8               | 13              | 17 | 143        |
| Periodontal healing                           | 50 | 6  | 44 | 7               | 12              | 17 | 135 (95 %) |
| Widened, diffusely outlined periodontal space | 3  |    |    | 1 <sup>x)</sup> | 1 <sup>x)</sup> |    | 5          |
| Radiolucency                                  | 2  |    |    |                 |                 |    | 2          |

x) Later healing after root filling with guttapercha.

Table 3. Results of roentgenologic evaluation of healing of initial changes roentgenographically demonstrated as widened, diffusely outlined periodontal space or radiolucency adjacent to some part of the root, after treatment with calcium hydroxide (I, II and IV) distributed according to mature (m) or immature (im) root; one case in II with ankylosis is excluded.

|                                               | I  | II |    | IV | Tot        |
|-----------------------------------------------|----|----|----|----|------------|
|                                               | im | m  | im |    |            |
| Number of teeth                               | 55 | 6  | 44 | 10 | 115        |
| Periodontal healing                           | 50 | 6  | 44 | 10 | 110 (95 %) |
| Widened, diffusely outlined periodontal space | 3  |    |    |    | 3          |
| Radiolucency                                  | 2  |    |    |    | 2          |

Table 4. Results of roentgenologic evaluation of apical closure and periapical healing of teeth with immature root (I and III) and of closure of the root canal in coronal fragment and periodontal healing of teeth with intra-alveolar root fracture (IV); teeth revealing ankylosis (III) are excluded.

|                                                                                  | I  | III | IV |
|----------------------------------------------------------------------------------|----|-----|----|
| Number of teeth                                                                  | 55 | 13  | 17 |
| Complete closure associated with periodontal healing                             | 50 | 9   | 13 |
| Incomplete closure associated with periodontal healing                           |    | 3   | 4  |
| Complete closure, associated with widened, diffusely outlined periodontal space  | 3  |     |    |
| Incomplete closure associated with widened, diffusely outlined periodontal space |    | 1   |    |
| No or incomplete closure associated with radiolucency                            | 2  |     |    |

Table 5. Roentgenologic evaluation of arrest of external root resorption associated with radiolucency in surrounding bone in luxated teeth (II) and of occurrence of progressive root resorption in luxated (II) and reimplanted teeth (III), after treatment with calcium hydroxide (II CH and III) or after root filling with guttapercha (II G), distributed in respect of mature (m) or immature (im) root.

| Number of teeth                                              | II CH |    | II G |    | III |    |
|--------------------------------------------------------------|-------|----|------|----|-----|----|
|                                                              | m     | im | m    | im | m   | im |
|                                                              | 7     | 44 | 18   | 15 | 21  | 17 |
| Arrest                                                       | 6     | 44 | 17   | 14 | x)  | x) |
| Progressive root resorption in association with radiolucency |       |    | 1    |    |     |    |
| Progressive root resorption in association with ankylosis    | 1     |    |      | 1  | 13  | 4  |

x) denotes 8 and 13 teeth, respectively, classified as healed in Table 2

Fig. 1. +I, boy, 9 years.

a) Before treatment 2 months after accidental luxation; apically divergent root canal, wide apical foramen, periapical radiolucency. b) Root filled with calcium hydroxide. c) 4 years after root filling with guttapercha and 6 years after beginning of treatment; apical closure and periapically periodontal space bordered by lamina dura.

Fig. 2. I+, boy, 7 years.

a) Root filled with calcium hydroxide 2 months after accidental luxation; periapical radiolucency. b) At the end of treatment with calcium hydroxide; apical closure and periapical bone healing. c) 4 years after root filling with guttapercha.

Fig. 3. +I, girl, 12 years.

a) Coronal fragment filled with calcium hydroxide 3 months after accident; at the root fracture widened, diffusely outlined periodontal space. b) After 12 months; closure of the canal in coronal fragment with hard tissue, periodontal healing. c) 4 years after root filling with guttapercha and 6 years after accident.

Fig. 4. +I, boy, 15 years.

a) Coronal fragment filled with calcium hydroxide 17 days after accident; radiolucency at the root fracture. b) Before obturation with guttapercha: hard tissue closure of the canal in coronal fragment, periodontal healing. c) 2 years after root filling with guttapercha and 5 years after accident.

Fig. 1

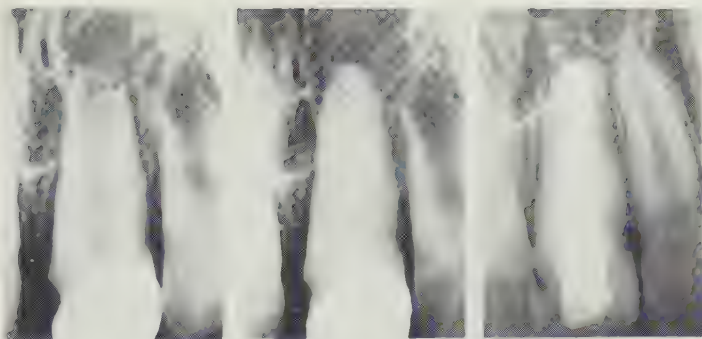


Fig. 2



Fig. 3

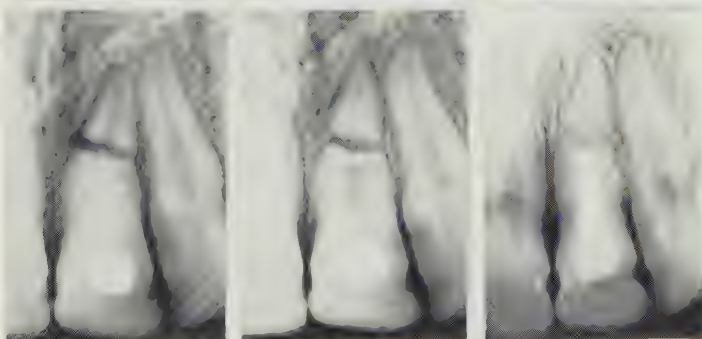
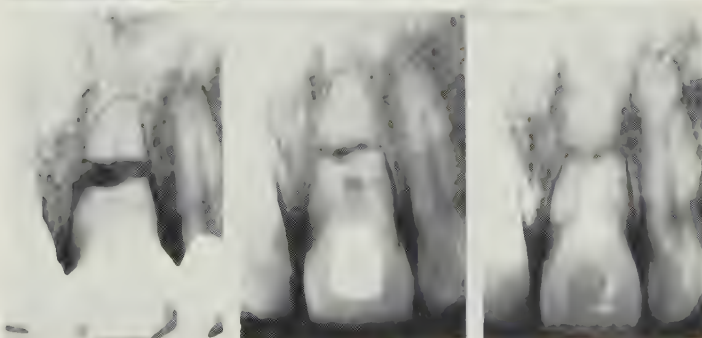


Fig. 4



a

b

c



Fig. 5. 1+, boy, 14 years.

a) 30 days after luxation: external root resorption associated with radiolucency in surrounding bone. b) Root filled with calcium hydroxide. c) 8 months after beginning of treatment: arrested root resorption and periodontal healing.

Fig. 6. 1+, girl, 12 years.

a) Root filled with calcium hydroxide 10 weeks after luxation; multiple root resorptions associated with radiolucency in adjacent bone. b) 8 months after: arrest of external root resorption and periodontal healing. c) 18 months after filling of the root with guttapercha and 42 months after luxation; residual defect on the root surface.

Fig. 7. +2, boy, 9 years.

a) At the beginning of treatment 30 days after luxation: external root resorption associated with widened, diffusely outlined periodontal space. b) One year after filling of the root with calcium hydroxide: arrest of root resorption, periodontal healing. c) 6 years after filling of the root with guttapercha and 8 years after luxation.

Fig. 8. -2, boy, 14 years.

a) Root filled with calcium hydroxide 65 days after reimplantation. The tooth was after luxation stored for 45 minutes in physiologic saline. b) After 6 months and c) 3 years after root filling with guttapercha or 4 years after reimplantation.



Fig. 5

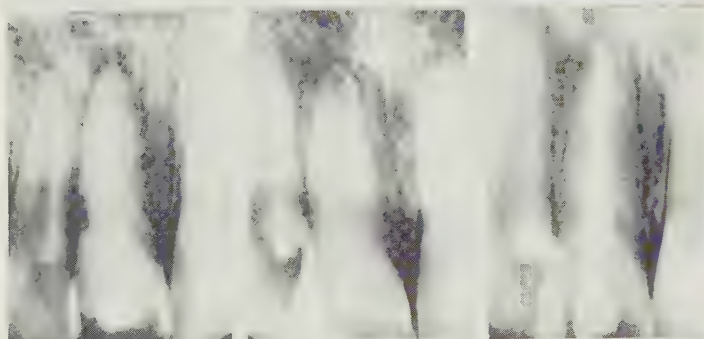


Fig. 6

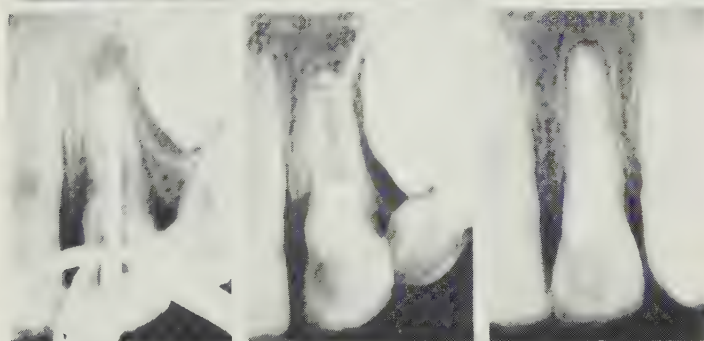


Fig. 7

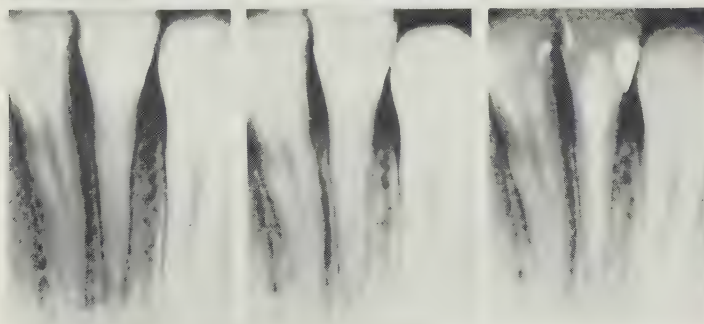


Fig. 8

a

b

c









